

Wave Attenuation on Muddy Bottoms Offshore Cassino Beach

A proposal submitted to the US Office of Naval Research
Proposed by

Susana B. Vinzon, D.Sc
Principal Investigator
Laboratory for the Dynamics of Cohesive Sediments
Federal University of Rio de Janeiro
Rio de Janeiro, Brazil
susana@peno.coppe.ufrj.br

and

Lauro Calliari
Co-Principal Investigator
Laboratório de Oceanografia Geológica (LOG/FURG)
Fundação Universidade Federal do Rio Grande – FURG
Av. Itália Km 8, s/n /Campus Carreiros
tsclauro@furg.br

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DURATION OF THE PROJECT: 2 years

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LONG TERM RESEARCH GOALS

To improve the understanding of the dynamics of shoaling waves and sediment transport in the coastal zone in areas with presence of significant cohesive sediment deposits.

PROJECT OBJECTIVES AND BACKGROUND

- 1) To assess the mud deposit formation
- 2) To assess the wave damping over the mud deposit when compared with the wave dissipation over a sandy bottom.
- 3) To observe the dynamics of the off shore mud deposits, concerning its shoreward limit.

1) MUD DEPOSIT FORMATION - It's hypothesized that the mud deposit offshore Cassino Beach is formed by deposition of fine sediments flushing from Patos Lagoon. Fine sediments originated in the basin are transported and temporally stored into the Lagoon, reaching the coastal area. The main hydrodynamic forcing are the astronomical and meteorological tides, controlling the water level over

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the Shelf, and the local wind and river discharge, controlling the water level inside the Lagoon. Episodically, sediments are carried out and deposit south of the mouth, in front of Cassino Beach.

Three tide gauges were installed along the coastline as part of project “WAVE ATTENUATION ON MUDDY BOTTOMS – A MULTIDISCIPLINARY FIELD STUDY OFFSHORE CASSINO BEACH, SOUTHERN BRAZIL” (referred as Cassino Experiment). There is no similar data previously collected. One ADV was located near the bottom, in order to assess the role of the wave drift as a trapping mechanism for the mud deposit formation. Furthermore, current, turbidity and salinity profiles were carried out from a boat in May 2005. This data set will contribute to the modeling efforts being carried out in the area.

The axis of the Lagoon and the coast orientation are northeast-southwest (NE-SW). The most frequent winds in the area, NE quadrant winds, cause set-up at the mouth of the lagoon and set-down in the coastal waters. Thus, a pressure gradient between them is created, driving currents outwards the lagoon and a large amount of sediments are exported to the shelf, transported southwards by the wind-driven currents, as illustrated in the simulations of Figure 1 and depicted in the satellite image in Figure 2.

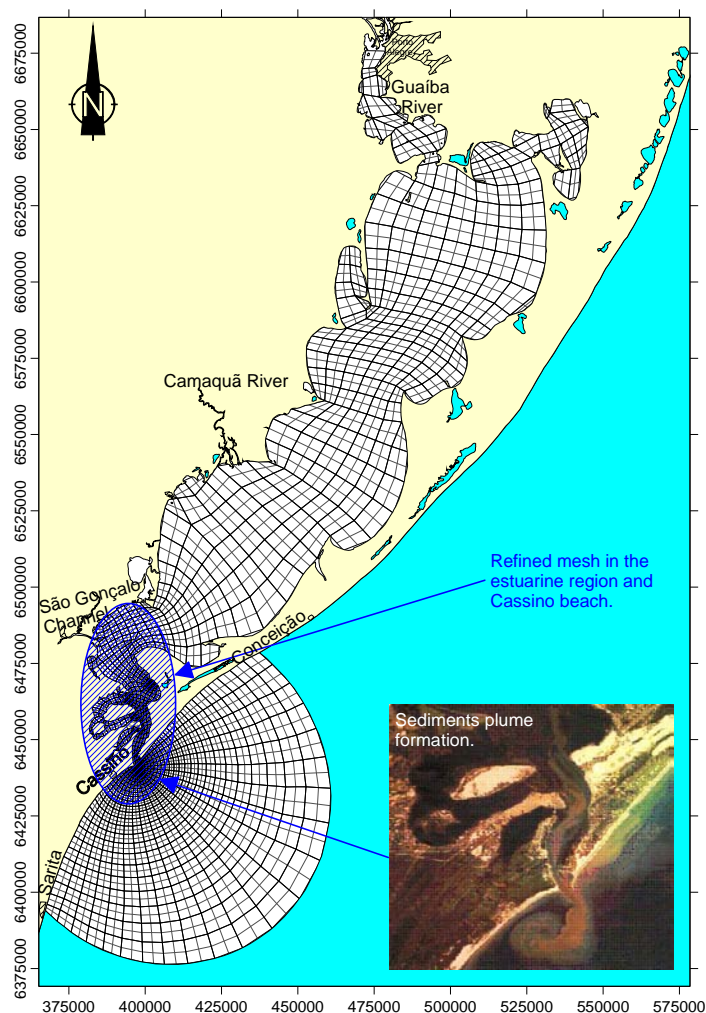


Figure 1a: Finite element mesh for the 2DH hydrodynamic model: dos Patos Lagoon and adjacent coastal area.

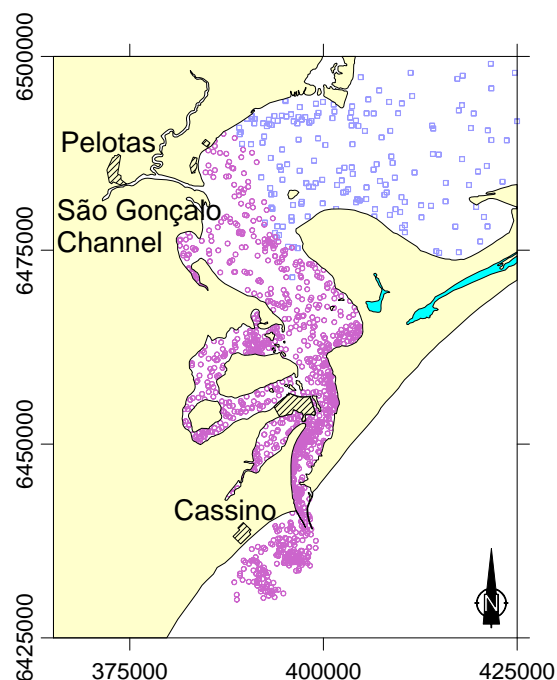


Figure 1b: Simulated typical sediment transport pattern for moderate north wind (5-8m/s) and low fresh water discharges.



Figure 2: The Patos Lagoon system flushing sediments out of the mouth (Modis image)

In this proposal, support is requested for a PhD student and for a Pos-Doc position to work on data analysis and modeling, attending this specific objective.

2) WAVE DUMPING OVER MUD DEPOSITS - Figure 3, shows the location of the mud patch in May 2005, as indicated by the surface and core samples, and the location of several instruments deployed. Three stations were instrumented in a transect through the mud deposit. One offshore, with a wave-rider measurement, located at 25m depth, which provides the wave entering the system. An intermediate, at 12 m depth, and the last one near the shore border of the mud patch, at 9m depth. Due to the high fishing activity it wasn't possible to implement a fourth station, as planned, which would be located at the off-shore border of the mud patch. In the station of 12m depth, an ADV measured currents at 1.5m from the bottom. In the station at 9m depth, waves and currents were measured with a NDP (Acoustic Doppler Profiler), and an ADV located 70cm from the bottom. At this station an array of 6 turbidimeters and an altimeter were deployed. Aiming to compare the wave attenuation through the muddy and sandy bottom, an ADV was deployed outside the mud deposit. Unfortunately the instrument was lost.

Regarding the wave attenuation and its relationship with the mud deposit and resuspension, Figure 4 shows some of the data collected (significant wave height at 25m and 9 m stations and one of the turbidimeter outputs), highlighting some of the processes occurring over the Shelf. One day period is evident in the turbidity signal during low energy wave periods with strong resuspension associated to the wave energy rising. A preliminary estimated value of the wave height at 9m depth station, considering the wave propagation from 25m depth after shoaling and rigid-bottom friction dissipation, super-estimates the wave height in 40 to 100% of the measured wave height values. It is hypothesized here that this is explained by the contribution of the mud bottom and must be accounted for differently than as the attenuation due to rigid-bottom. Mud-waves interaction has a strong coupling. In particular, it is proposed to investigate the wave damping resonance related to the thickness of the mud bottom and their geotechnical/rheological characteristics. For this purposes cores and surface samples were under geotechnical and rheological tests.

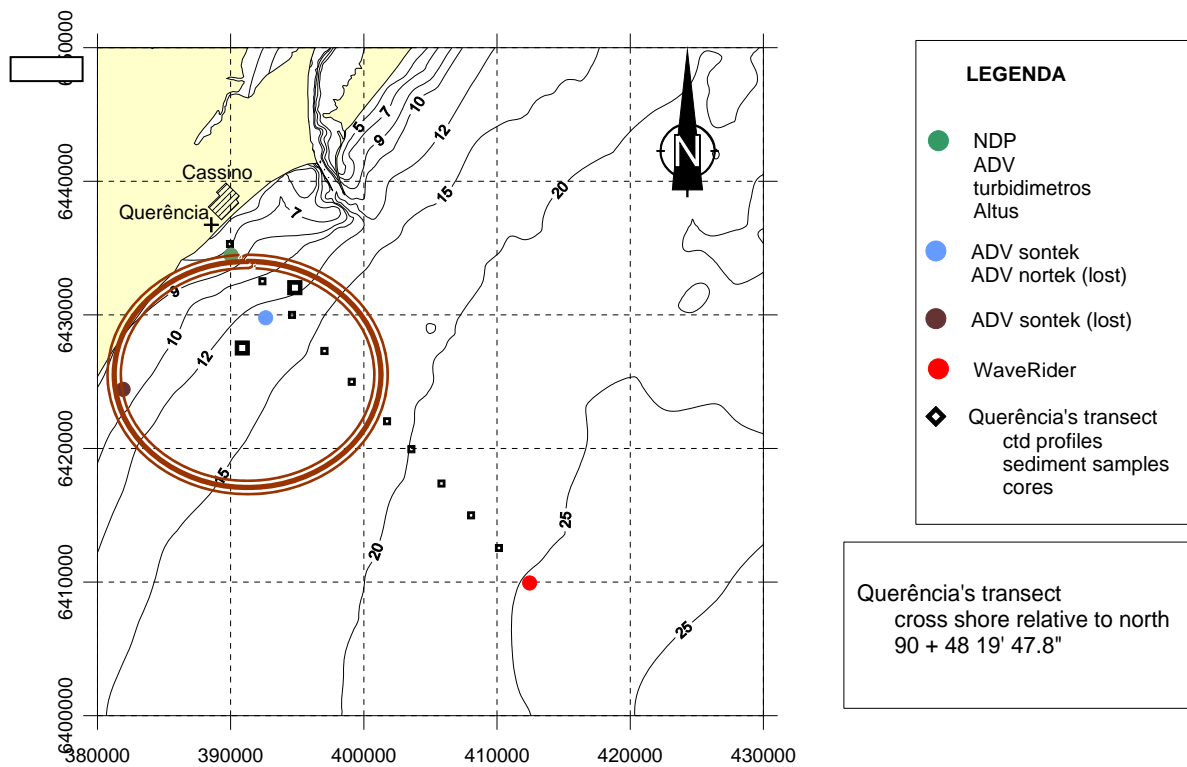


Figure 3: Bathymetry and instruments deployed in the Cassino Experiment

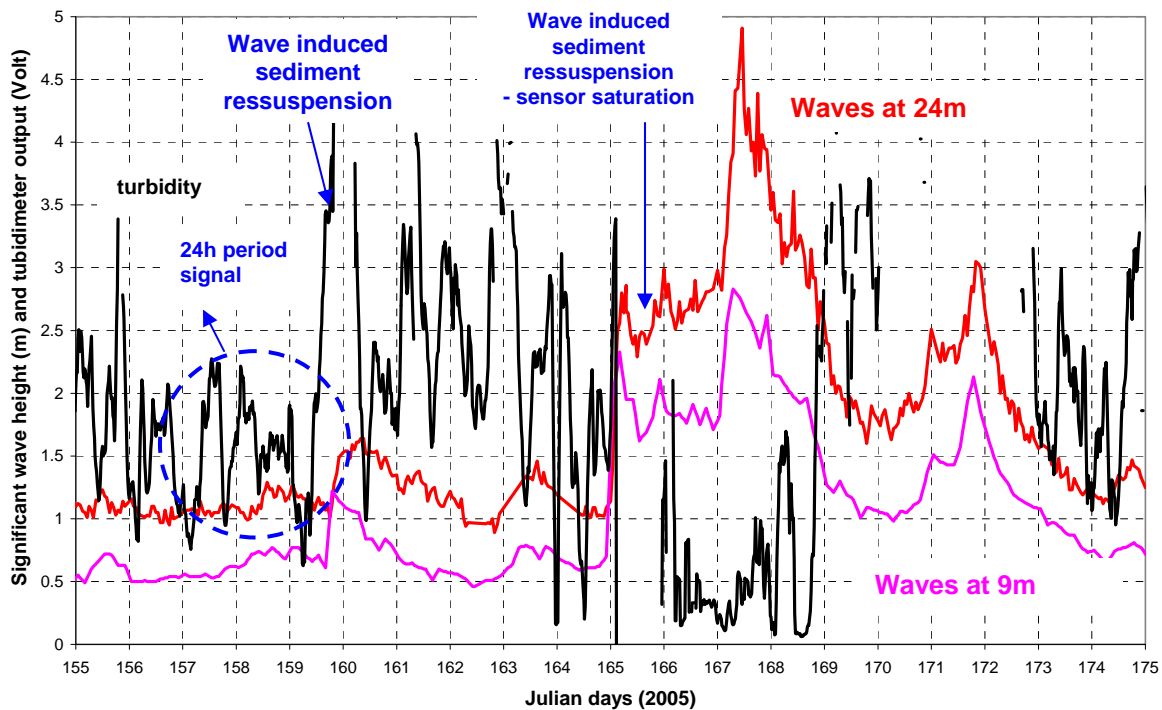


Figure 4: Significant wave height along the mud deposit and signal of turbidimeters. It is observed larger wave attenuation than could be expected for a rigid bottom and strong sediment resuspension (indicated by the saturation of the sensors) associated to the increase in the wave energy. Data from Cassino Experiment

In this proposal, support is requested for a PhD student (partial support) to work on data analysis and modeling, attending this specific objective.

3) **MIGRATION OF THE MUD DEPOSIT.** During Cassino Experiment did not occur events of mud migration to the beach. However, the measurements of the currents in the vertical profile and at a specific location near the bottom, together with turbidity measurements, may highlight the mechanisms for the movement of the mud under the different hydrodynamic forcings. For example, Figure 5 shows one sample of the velocity measurements near the bottom at the 9m station with a resultant towards the coast. Further analysis is needed to stress which mechanisms are responsible for the movement of the mud, in order to conclude about why the fine sediments accumulate in this mud deposit and under which conditions it migrates to the beach.

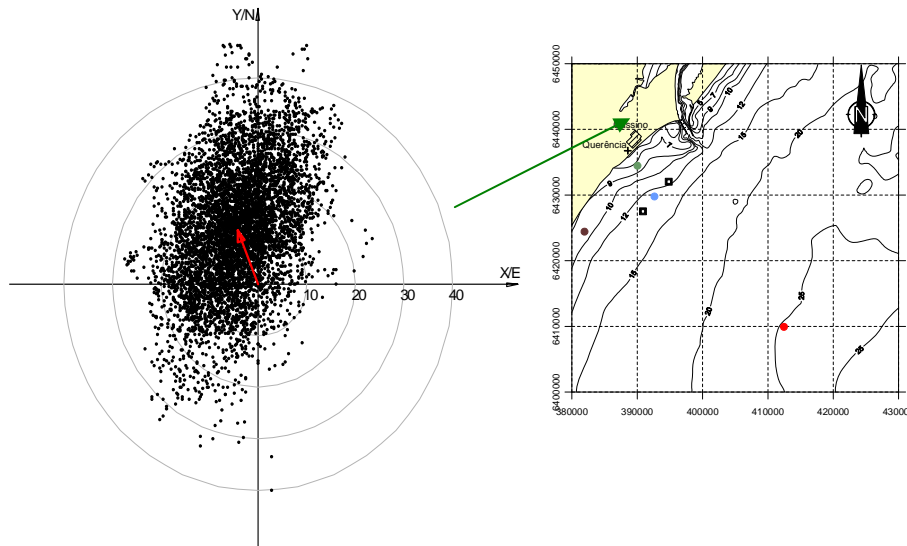


Figure 5: Scattering diagram of near bottom velocities at 9m depth station of one single record.

A remarkable observation was done during the beach profile surveys, by NRL researchers during the Cassino Experiment, using the instrumented jet-ski. The signal of the echo bathymeter changed when the bottom changed from sandy to muddy, as shown in Figure 6. It is proposed here to continue this surveys, in collaboration with Todd Holland, NRL, Stennis, maintaining the near-shore observation system ARGUS, installed during Cassino Experiment. The imagery will also be used to get information about the amount of nearshore dissipation when an eventual mud event occurs. We did not monitor one mud migration event yet but certainly will over the long term. The jetski survey is critical for a “rapid response” survey to get the bathymetry necessary to run nearshore models of wave dissipation over mud. Cores and grab samples will be also collected to establish whether the nearshore mud is really from the lagoon and to more thoroughly verify the “acoustic” signal interpretation.

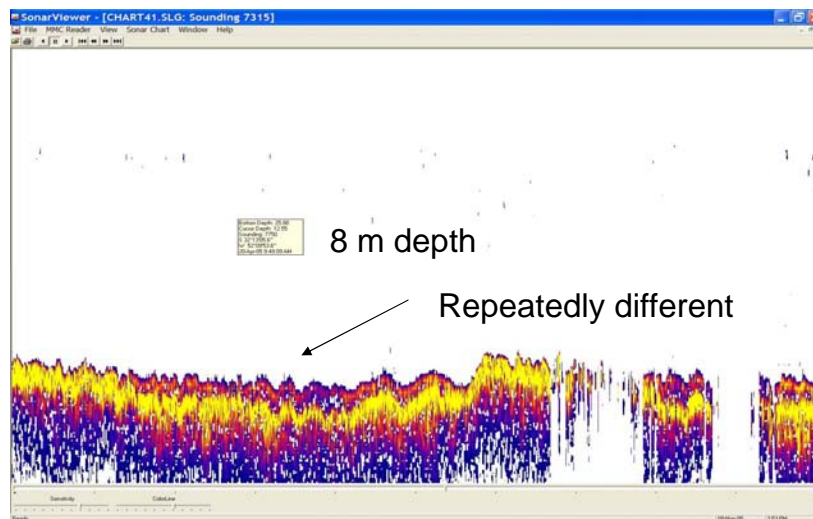


Figure 6: Changes in the signal of the echo bathymeter due to changes in the bottom sediment characteristics.

In this proposal support is requested in order to maintain the video-camera ARGUS system, to acquire proper instrumentation to monitor the mud patch mobility in the coastline (jet-ski and echo bathymeter), and to maintain one station for wave measurement. During the extension of the project periodic surveys (twice a month or more if the meteorological conditions permit) will be performed. Together with the observations through the video-camera system, this will generate a important data base about the influence of the mud position in the coastal morphodynamics. A Master student will be involved in this measurement program.

Collaborations

This project will be developed in collaboration with Todd Holland from the NRL, at Stennis. Also, we expect to continue the collaborative worked started at the NICOP project “WAVE ATTENUATION ON MUDDY BOTTOMS – A MULTIDISCILPINARY FIELD STUDY OFFSHORE CASSINO BEACH, SOUTHERN BRAZIL” (Award Number: N00014-04-1-0274 and N00173-04-1-G901), between several Brazilian institutions (Universities of Rio Grande, Itajaí, and Rio de Janeiro and Brazilian Navy), the Naval Research Laboratory, and Delft Hydraulics, from Netherlands. In 2006 an International Symposium is being organized as part of this project, where we are going to have the opportunity to discuss the results of the ongoing and completed work.

PARTICIPANT INSTITUTIONS

- 1- Federal University of Rio de Janeiro (UFRJ) / Laboratory for Dynamics of Cohesive Sediments
 - a. Principal Investigator, in charge of the management of the project
 - b. Lutocline and wave-mud interaction analysis
 - c. Formation of the mud deposit
- 2- University Foundation of Rio Grande (FURG) / Geological Oceanography Laboratory
 - a. Logistic support and field measurements
 - b. ARGUS system maintenance

3- Brazilian Navy / Directorate of Hydrography and Navigation / Navy Hydrographic Center

The fieldwork will be carried out on the continental shelf of Brazil. For that reason, official permission must be granted and the participation of the Hydrographic Center (“Centro de Hidrografia da Marinha” - CHM) will certainly be a contributing factor to the approval of the project.

a) Deployment of the wave measurement device.

4- University of the Vale do Itajaí (UNIVALI)

a) ADV deploy at 10m (logistic and data retrieval)

b) Turbidity, salinity and current measurements analysis

c) Wave damping analysis

WORK COMPLETED

The work done until September 2006 was the organization of the International Symposium on Mud Deposit in Coastal Areas, to be held in Porto Alegre, November 13-17, 2006. Attached is the program of the meeting. A dedicated workshop to the project will be held on November 16 and 17, as described in the program. More details about the symposium at www.oceanica.ufrj.br/costeira/eventos/mudcoast

RESULTS

Due to a delay in the fund disbursement other activities have not started yet, and so there are no other results to describe.